Intermittency Analysis Project

Interim Results for Tasks 3+4

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Intermittent Generation

- Wind
  - Variations cover many timescales
  - Season, day, hour, minute
- Solar
  - Variations are dominated by day/night cycle
- Biomass and geothermal generation are not intermittent

Time Scales for System Planning and Operation Processes

Slower (Years)

Time Frame

Faster (seconds)

Long-Term Resource and Capacity Planning

Capacity Value

Unit-Commitment

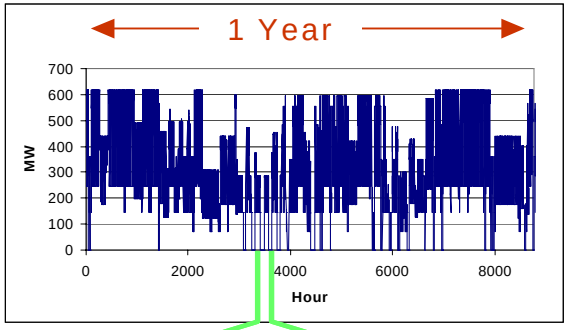
Day-Ahead Scheduling

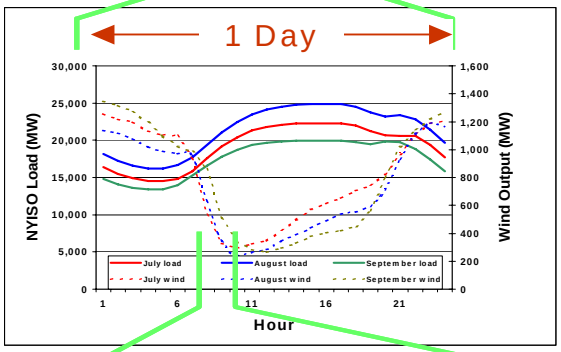
Multi-Day Forecasting

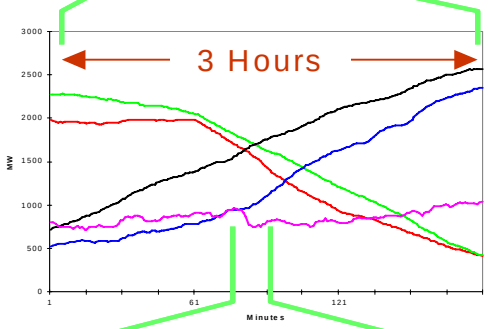
Load-Following
(5-minute dispatch)

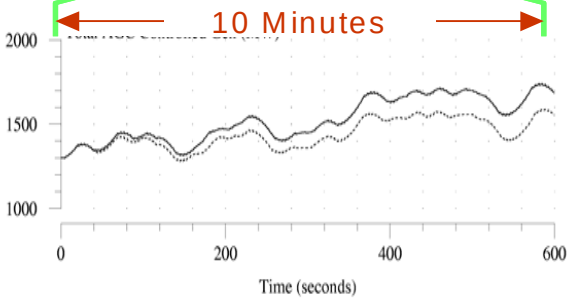
Hour-Ahead Forecasting

Frequency and Tie-Line Regulation (AGC)









Objectives

- Evaluate California grid operation with increasing levels of wind generation
  - Penetration of wind up to RPS levels
  - Intentionally push system beyond expected level of wind penetration for year 2020
- Identify and quantify system performance and operation problems
  - Load following, regulation, minimum load, etc.
- Identify and evaluate possible mitigation methods

IAP Builds on CERTS Conclusions

- Refined 2010 mix used in CERTS analysis
- Expanded the analysis to include multi-year statistics vs 2004 only
- Focused on wind and solar (intermittents)
- Included geographic diversity of renewable resources
- Incorporated wind forecasting into scenario development (AWS Truewind)
- Evaluating types of future generation needed to accommodate variable renewables

Four Scenarios To Be Analyzed

- 2006 Base Case – Existing transmission system with existing mix of generation resources
  - Includes 1976 MW wind and 332 MW solar
- 2010 Tehachapi Case – 20% Renewable Energy
  - 7550 MW wind and 1864 MW solar in California
  - Includes 3787 MW of wind at Tehachapi and new 500 kV transmission to support it
  - *Note: This case is designated* "2010T"
- 2020 case with 33% renewable energy
- Higher penetration level

Two Scenarios Under Study

	2006	2010T
Peak California Load, MW	58,634	64,297
Peak CAISO Load, MW	48,494	53,178
Total Geothermal, MW	2398	4130
Total Biomass, MW	764	1184
Total Solar, MW	332	1864
Total Wind, MW	1976	7550
Wind at Tehachapi, MW	760	3787

Wind and Solar Generation in California

	2006	2010T
Concentrating Solar (CS)		
Number of Sites	9	12
Total CS MW	332	1235
Photovoltaic (PV)		
Number of Sites	0 *	136
Total PV MW	0 *	629
Wind Plants		
Total Number of Sites in CA	57	99
Sites in Tehachapi	16	36
Total Wind MW	1976	7550

** Existing PV aggregated with load*

Scenario 2010T

	Wind		Conc. Solar		PV Solar		Total Wind+Solar	
	MW	%	MW	%	MW	%	MW	%
CAISO	7310	97%	1235	100%	448	71%	8993	96%
Non-CAISO	240	3%	0	0%	181	29%	421	4%
Total CA	7550	100%	1235	100%	629	100%	9414	100%

96% of Wind and Solar generation is in CAISO operating area

Types of Analysis

Interim results today

- Statistical Analysis
  - Multiple time periods
- Production Cost Simulation with MAPS
  - Hour-by-hour simulation of grid operations for an entire year

Future work included in IAP

- Quasi-Steady-State Simulation with PSLF
  - Minute-by-minute time-sequenced power flows for entire WECC grid for several hours
- Transient Stability Simulation with PSLF
  - Impact of wind generation on grid stability

Data

- Powerflow data from Davis Power Consultants
  - Scenarios 2006 and 2010T
- Load data from CAISO, 2002-2004
  - Hourly load MW, forecast and actual
  - 4-sec load MW for about 400 days
  - Load data scaled up to peak for 2006 and 2010
- Wind data from AWS Truewind, 2002-2004
  - Hourly wind MW, forecast and actual
  - 1-minute wind MW for 51 selected periods
  - Separate profile data for each wind farm
- Production simulation data for California and WECC from Rumla, Inc.

Data

- Solar data from multiple sources
  - Hourly and 1-min MW for Sungen and Luz for 2002-2004 (CAISO and UC-Davis)
  - Hourly Stirling solar MW for Mojave and Imperial for 2002-2004 (NREL and SES)
  - Hourly and 15-min Photovoltaic MW for on year, aggregated by zip code (CPUC - SGIP)
  - 1-min solar insolation data at one site, for January and July 2002 (NREL, ARSC SUNY Albany)

Based on this data, GE compiled solar profiles for multiple sites across California

Interim Results for 2006 and 2010T

- Statistical Analysis of 2006 and 2010T
  - Nick Miller
- Production Simulation Analysis of 2010T
  - Gary Jordan
- Operational Implications, Initial Observations, and Next Steps
  - Nick Miller and Gary Jordan

Focus on impacts due to intermittency in MW

✓ Cover lots of material

✓ Give an overview of types of analysis performed

✓ Show interim results